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Simulation in Training Workshop 2012

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ABSTRACT

This report summarises key outcomes from a half-day workshop on Simulation in Training held as part of the Defence Human Sciences Symposium (DHSS) in November 2012. The workshop involved presentations on simulation-based training (SBT) research within DSTO, and syndicate group discussions aimed at addressing key questions relating to SBT. The workshop outcomes highlighted the need for the research community to obtain more evidence regarding the cost-effectiveness of simulation and for the defence client to adopt more rigorous processes when acquiring and evaluating simulation. At present, knowledge gaps are limiting the research community's ability to provide Australian Defence Force (ADF) customers with sound advice regarding the effectiveness of SBT and for the ADF to fully realise the benefits associated with SBT.

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Simulation in Training Workshop 2012

Executive Summary

Defence forces worldwide are seeking to increase the use of simulation for training and education. However, stakeholders within the defence and research communities, as well as industry, are asking questions which indicate a level of uncertainty regarding the best use of simulation. These questions relate to where in the training continuum simulation-based training (SBT) should be used, the optimum mix of live training and SBT, and the required level of simulator fidelity. However, opportunities for collaboration between stakeholders, which might help to address these questions, are limited. One such opportunity arose during the 2012 Defence Human Sciences Symposium (DHSS)[1]. Accordingly, a workshop entitled "Simulation in Training" was conducted during DHSS 2012 with the aim of discussing key issues for SBT. The workshop was attended by 27 personnel from DSTO and other defence agencies, along with representatives from academia.

The workshop involved a series of presentations on SBT research within DSTO, followed by syndicate group discussions focussed on (1) providing advice to the client on the use/acquisition of simulation, (2) engaging with industry regarding simulation development, (3) cost-effectiveness of SBT, and (4) future research / high pay-off areas for SBT. The workshop outcomes included an increased awareness of SBT research within DSTO, the identification of key issues, challenges and lessons for SBT research, as well as providing an increased network of contacts involved in SBT research. The workshop also highlighted (1) deficiencies in the acquisition and use of SBT within the Australian Defence Force (ADF) and (2) limitations in the advice researchers can currently provide to defence clients regarding the best use of simulation. The implications of this are that the ADF may not be maximising the potential benefits of SBT, and that researchers and clients need to identify the specific studies and resources required to start addressing this situation. Based on the workshop outcomes, a number of lessons were identified for both the research community and the defence client:

- More research is needed to inform our understanding of the cost-effectiveness of SBT, including a better understanding of the relationship between simulator fidelity and training effectiveness, determining which skills are best trained using SBT, and developing more reliable measures of effectiveness.

[1] The Defence Human Sciences Symposium is the annual meeting of the DSTO Human Sciences Hub which comprises researchers from DSTO, as well as academics and practitioners from the wider scientific community with an interest in human sciences research.

- Principles of training and education such as guided instruction and consideration of individual differences (e.g., ability, learning styles) are important when delivering SBT.
- There are likely to be benefits from using SBT to train for high-risk missions, and the development of critical thinking, decision making skills, and other non-kinetic skills (e.g., cultural awareness).
- There is a need for defence clients to follow more rigorous processes when acquiring a simulation capability, including better definition of training requirements and simulation specifications and using cost-benefit analysis to compare training options.

Contents

1. INTRODUCTION 1

2. WORKSHOP OUTLINE 1
2.1 Opening Remarks 2
2.2 Individual Presentations 2
2.3 Syndicate Group Discussions 3

3. KEY OUTCOMES 3
3.1 Individual Presentations 3
3.2 Syndicate Group Discussions 5
3.3 Constraints 10
3.4 Additional Material 11

4. CONCLUSION 11

5. REFERENCES 12

APPENDIX A: WORKSHOP ATTENDEES 14

APPENDIX B: SUMMARY OF DSTO STUDIES 15

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1. Introduction

On 13 November 2012, DSTO Land Operations Division (LOD)[1] hosted a half-day workshop on 'Simulation in Training' as part of the 2012 Defence Human Sciences Symposium[2]. The main driver for the workshop was to address an enduring request from defence clients for advice on how to best use simulation within the training continuum. At present defence forces are seeking ways to increase their use of simulation in order to deliver more effective and efficient training. While several groups within the Australian Defence Organisation and the wider academic community are attempting to tackle these issues, much of the work is being done in isolation. The workshop provided an opportunity to discuss these issues in person with key stakeholders who were attending the symposium.

Within Australia, key stakeholders in the simulation-based training (SBT) domain include various groups within the Defence Science and Technology Organisation (DSTO), the Australian Defence Force (ADF), Australian Defence Simulation Office (ADSO), the wider scientific community, and Defence Industry. The objective of the workshop was to bring together personnel from these groups to identify key issues, challenges and lessons from the use of simulation in training, in order to establish a basis for further discussion in the area, and ultimately, to provide informed advice to clients regarding the use of SBT.

This report summarises the key outcomes from the workshop based on notes collated from individual presentations and syndicate group discussions. The report is aimed primarily at the research community to inform future research in support of defence clients; however implications for defence clients and industry are also highlighted.

2. Workshop Outline

The workshop was attended by 27 personnel who were mostly from DSTO and other defence agencies, with some representation from academia (See Appendix A for the list of attendees and their affiliation). The majority of attendees were either working in, or had an interest in, SBT research and most were responsible for providing advice to decision-makers regarding the acquisition and use of simulation for training. The workshop program consisted of an opening address, several individual presentations, and syndicate group discussions. Each of these activities is described briefly below.

[1] The workshop was facilitated by Dr Ashley Stephens with assistance from Mr Philip Temby (LOD) and Dr Susannah Whitney (LOD).
[2] The DHSS is the annual meeting of the DSTO Human Sciences Hub which comprises researchers from DSTO and academics and practitioners from the wider scientific community. The symposium and workshop were held at the Mawson Centre in Adelaide, South Australia.

2.1 Opening Remarks

The workshop commenced with the facilitator giving a short presentation that outlined the context for the workshop, as well as the scope of SBT within the ADF. It was noted that the scope includes: training and education, live, virtual and constructive (LVC) simulation, individual and collective training, and distributed versus co-located training. In addition, the facilitator highlighted that the following questions are typically being asked by defence clients in relation to SBT.

1. What are the advantages and disadvantages of SBT?
2. How do we measure the effectiveness of SBT?
3. Where in the training continuum should SBT be used?
4. What is the optimum mix of live and simulation-based training?
5. What level of (simulation) fidelity is required?

Due to the limited time available, it was not expected that workshop attendees would be able to answer these questions. However, they were highlighted to raise awareness of the questions being asked by defence clients, and to encourage attendees to think about how they might answer them. It was also envisaged that the questions would provide a starting point for further discussion within the research and defence communities.

2.2 Individual Presentations

Six presentations on SBT were given by DSTO staff in order to share lessons from DSTO research with the workshop participants. The presentations covered a range of areas (e.g., individual and collective training, military education), different simulations (e.g., first-person shooter, microworlds, flight simulators) and different domains (e.g., air, land). The list of presenters and their presentation titles are shown in Table 1.

Table 1: List of workshop presenters and presentation titles

Presenter and Affiliation	**Presentation Title**
Dr Ashley Stephens (LOD)	Simulation in Training
Dr Susannah Whitney (LOD)	Use of Simulation in Individual versus Collective Training
Dr Greg McLean (AOD)	Exercise Black Skies 12: Evaluation of the effectiveness of synthetic collective training for an Airborne Early Warning & Control team
Dr Greg McLean (AOD)	The Integration of Simulation within an *ab initio* Pilot Training Program
Mr John Hansen (C3ID)	Professional Military Education
Dr Daniel Goodburn (C3ID)	The State of Simulation within Education

2.3 Syndicate Group Discussions

Following the individual presentations, workshop participants were split into three syndicate groups. The purpose of this session was for participants to discuss and generate responses to the following questions.

1. What key messages would you provide to clients regarding the use / acquisition of simulation for training?
2. When is simulation-based training cost-effective: what does effective mean to you?
3. How would you engage with industry in order to achieve best return on investment for simulation-based training?
4. Where should future research in simulation-based training focus? Where are the high pay-off areas, and why?

These questions were selected by the workshop organisers for the following reasons: (1) they were sufficiently high level to enable/encourage all workshop participants to contribute to the discussions[3]; (2) they were consistent with the questions being asked by defence clients regarding SBT; (3) they focused on identifying key messages for clients and industry; and (4) they focused on addressing future areas for SBT research.

Participants were given 40 minutes to discuss the questions in their groups and were then asked to report back to the main group their discussion outcomes (20 minutes). Due to the limited time available, it was not expected that the questions could be addressed in any great depth, but rather provide an opportunity to collate key points for further discussion and follow-up with those interested in SBT after the workshop.

3. Key Outcomes

3.1 Individual Presentations

The following sections summarise key lessons highlighted in the presentations of recent DSTO research examining the use of SBT. More details about each of the DSTO studies are provided in Appendix B.

- **More empirical research is needed.** It was highlighted by one presenter that one of the difficulties in providing reliable advice to the client results from the broad range of areas covered by SBT. The implication is that the effectiveness of SBT may need to be evaluated for each specific case of interest; lessons generated from one case may not generalise to other cases. Consequently, a large body of knowledge is required in order to confidently provide meaningful advice to the client regarding the use of SBT. At present, there remains a lack of empirical research into SBT to inform such advice.

[3] This was an important consideration given that not all workshop attendees were undertaking research in SBT but had an interest in the area.

- **SBT appears to be more effective for certain skills.** It was highlighted by another presenter that the utility/effectiveness of SBT can be dependent on the skill(s) being trained. In one DSTO study, the VBS2 simulation was found to be ineffective for collective training in a specific collective context (i.e., section attack training for infantry teams) but showed promise for individual training in a different collective context (e.g., hazard awareness training for individual commanders of a vehicle convoy). The implication is that it is important to specify the task and context in which the training is conducted and not simply describe a simulation as being effective (or not effective) for training. It also implies that in some cases, SBT may be more effective when training individuals in a collective context, than training teams in a collective context. Such principles may be helpful for defence clients to consider when employing SBT; however, more case studies are needed before definitive conclusions can be made.

- **Limitations in simulator fidelity can influence SBT effectiveness.** The ability to replicate aspects of the real-world in a simulation can be critical to SBT effectiveness. For example, limited field-of-views on desktop displays can reduce an individual's level of situational awareness during training, especially when they need to know where their other team members are located in the virtual environment. The implication here is that simulator fidelity needs to support the tasks being trained to a sufficient level; otherwise it will limit the degree of training effectiveness that is achieved. It also implies that where the requirement for situation awareness is high (and cannot be supported by simulation) then other training methods may be more appropriate.

- **SBT may not always be cheaper.** There is often a perception that SBT is cheaper than live (or traditional) training methods; this is particularly true in the air domain. However, in one DSTO study it was found that there was little difference in cost between an all live and a blended training program involving simulation for pilot training. The lesson here is that it should not be assumed that the use of SBT automatically achieves cost-savings. Furthermore, there can be hidden costs associated with delivering SBT, such as costs associated with hardware and infrastructure, software development and specialist support services; some of which may be significant and ongoing (e.g., maintenance and development costs).

- **Realistic SBT can be resource intensive.** It was noted by one presenter that SBT can be effective for improving collective skills and mission performance in the air domain. However, to achieve such outcomes, a 4:1 ratio of white force to exercise participants was required. The implication is that conducting realistic SBT can be highly resource intensive, and may not be achievable on a frequent basis if the client incorporated SBT into their regular training program. Further research is required to examine whether this ratio can be reduced (e.g., through greater use of simulated entities, using non-expert role players) without compromising training effectiveness.

- **Opportunities for using simulation are being missed.** Another presenter highlighted that a recent review into the state of simulation in the field of education[4] indicated that (1) developments in simulation tends to focus on training rather than education, (2) there is a lack of focus on using simulation to help trainees develop critical thinking skills, creativity and the ability to deal with ambiguity, and (3) there is a gap between research in instructional design for simulation-based education and simulation development. The implication of these issues is that there are opportunities being missed in developing and using simulation to support education of military personnel. It was highlighted that microworld simulations may be useful tools for addressing this issue, by raising awareness of different thinking styles and for training skills such as adaptability. There is currently some research within DSTO and overseas defence agencies that is examining the utility of such tools for training and education purposes.

3.2 Syndicate Group Discussions

Following the presentations, the workshop attendees were split into three syndicate groups. The key points and themes raised by the groups to each of the four questions are summarised in the following sections.

What key messages would you provide to clients regarding the use / acquisition of simulation for training?

Participants highlighted several points in relation to this question. Overall, participants acknowledged that SBT has potential advantages and there is much anecdotal evidence regarding the utility of SBT. However, participants noted that there remains a lack of empirical research into the effectiveness of SBT, which was perceived to be a major impediment in providing meaningful advice to clients. In particular, it was noted that there appears to be a lack of case studies demonstrating clear evidence for the benefits of SBT. The implication of this situation is that clients may not be using simulation in the best possible way; in the worst case, it is possible that SBT may lead to negative training. It also implies that there is a need for researchers and clients to work together to identify the specific studies and resources required to start addressing this situation.

In terms of simulation acquisition, participants made some specific points regarding the need for the client to take a more rigorous 'systems' approach to the acquisition of SBT. This means that the contribution SBT makes to overall capability needs to be understood (as with all training); in this regard, the acquisition of simulation should potentially be treated like any other capability. Consequently, participants believed that the acquisition process needs to include the rigorous specification of simulation requirements and be based on a Training Needs Analysis (TNA). However, some participants questioned the quality of TNAs being conducted within Defence, and noted that, in some cases, there appeared to be no TNA conducted at all. This is clearly an impediment for Defence in terms of getting value-for-money from SBT; if training requirements are not being

[4] Magee, M. (2006). A State of the Field Review: Simulation in Education Final Report. Alberta Online Learning Consortium. Calgary Alberta, Canada.

properly articulated as part of a TNA, it seems unlikely that simulation specifications are being properly addressed.

It was noted that, within the ADF, the acquisition of simulation occurs either as a very minor part of a major capability acquisition, or as a minor capability acquisition and hence may not be subject to the same level of rigour as a major capability. However, participants felt that this policy is based on an argument that a low up-front cost equates to low-risk, which may not be justified, particularly when taking into account costs throughout the capability lifecycle (e.g., costs associated with simulator upgrades). For the client, there can be a tension between following a formal acquisition process for simulation acquisition (including requirements definition and TNA) and choosing to acquire COTS products. The first option may be more expensive in the short term, but is more likely to deliver cost-effective training in the longer term. Buying COTS products is more convenient, and possibly quicker and cheaper in the shorter term, but may result in training shortfalls and other costs in the longer term.

Participants also highlighted that 'low-technology' approaches can provide effective training and that SBT should not automatically be assumed to be the best (or cheapest) option. Two examples were provided to illustrate this point. One example was the use of small group discussions to 'wargame' contingency plans for specific scenarios with aircrew trainees. It was highlighted that this type of training can be very effective in teaching aircrew tactics and teamwork. The second example was the use of mental checklists (e.g., if A occurs, then do B) to help aircrew trainees cope with high levels of cognitive workload in stressful situations. There are likely to be other examples within the ADF.

Participants also highlighted a number of important principles and concepts that could be applied when using SBT. The following examples were provided:

- **Guided instruction**: There was consensus that using guided instruction is an important ingredient for effective training. It was acknowledged that using simulation and other training technologies can enable more efficient training and increased training throughput (e.g., through self-paced learning). However, participants felt that there is a risk in relying on technologies to deliver training and expecting trainees to automatically assimilate the necessary information; in some cases, trainees will require guided instruction and feedback. Traditionally, this is provided by instructors/teachers; however, developments in areas such as automated intelligent tutoring may be able to provide this capability in the future.

- **Training beyond competency levels**: It was noted that due to resource and time constraints, the current training model within Defence is based on competency based training. This approach does not allow the degree of practice required to achieve higher levels of proficiency (i.e., training to mastery), nor does it allow opportunities to assess the capability limits of operators during training. This was seen as a shortfall in current training practices which could potentially be addressed (in part) by using SBT. This is because simulation can allow additional practice without incurring significant additional cost, as well as providing a safe environment in which to push operators to

the limits of their performance (e.g., driver fatigue). Consequently, this was also identified as an area for future research into SBT.

- **Training versus Education**: As noted in Section 3.1, there appears to be a tendency for simulation development to focus on training rather than education; consequently, there is a risk that SBT may focus on teaching trainees 'what to think' (e.g., through exposure to relevant scenarios and having to respond with the 'correct' response). It was acknowledged that training personnel 'what to think' may be appropriate for certain military populations and under certain circumstances (i.e., responding instinctively to certain situations, obeying orders). However, in some cases, personnel may be required to make decisions under conditions of uncertainty and ambiguity, where such an approach is not effective. Consequently, there is a need to educate personnel in 'how to think' (e.g., creative thinking and problem-solving, working through different courses of action and seeing the different consequences.) This was also identified as an area for future research.

- **Realistic training**: Current military training models advocate a 'crawl-walk-run' approach to training; that is, starting with simple tasks and progressing to more difficult tasks. However, the effectiveness of training practices that involve getting learners to attempt difficult and challenging tasks in the early stages of training (i.e., 'throwing them in the deep end') was discussed. As a rule this practice was not recommended by participants but there was agreement that providing trainees with challenging experiences in a non-judgemental learning environment (i.e., devoid of formal assessment and no criticism for making errors) may produce good learning outcomes. This concept was also identified as an area for future research into SBT.

When is simulation-based training cost-effective?

Overall, the consensus among participants was that there is currently insufficient empirical evidence to provide a definitive answer to this question. Notwithstanding this, a number of issues relating to the evaluation of cost-effectiveness were highlighted.

Participants believed that the critical measure of training effectiveness was real world ('on-the-job') performance, although there was little discussion as to how this could be reliably measured. It was felt that there was a lack of good measures of effectiveness for SBT; one suggestion was to apply a checklist of criteria (including cost, risk and training benefit) to help make decisions about when to use SBT. It is worth noting that while this suggestion seems reasonable, actually determining these criteria would not be a trivial exercise.

In this respect, it was believed that simulation should be considered as just one tool for supporting training and that statements regarding cost-effectiveness need to be made relative to other training methods (e.g., traditional instruction, live training). However, participants indicated that there was a lack of empirical data on the effectiveness of conventional training methods, which limits the ability to make reliable comparisons with new training methods such as SBT. This is an important point; if the cost-effectiveness of current training methods is not fully understood, it makes it difficult to make informed decisions regarding new training methods, including the acquisition of simulation.

In addition, it was noted that within the military domain there was a strong reliance on subject matter expert judgement, with a lack of more objective measures. This was thought to be an impediment to the progress of training research, as well as limiting the ability to evaluate cost-effectiveness.

Participants also raised a number of specific questions that highlighted gaps in our current knowledge of SBT.

- How do skill acquisition and retention rates for SBT compare with those for traditional training? It is conceivable that skill retention is different for SBT compared with conventional methods; however, the rate of skill degradation for both training methods is not known. Hence at present, it is not possible to compare the long term effectiveness of SBT and conventional training. It was noted that the long term effectiveness of SBT has implications for the scheduling of refresher training and the overall cost-effectiveness of SBT relative to conventional training.

- What type of training is most effective for a specific task? And what level of simulation fidelity is required? Participants agreed that certain skills appear to be more suited to SBT than others, but it was noted that the relationship between simulation fidelity and training effectiveness is not fully understood, and may need to be established in each specific case. This is an important issue, as higher fidelity usually equates to higher cost; however, higher fidelity may not be justified unless it results in more effective training.

- What impact do individual differences (e.g., ability, personality, learning styles) have on training outcomes? Does SBT benefit everyone equally? Participants were not able to answer these questions specifically for SBT. However, it was noted that a 'one-size fits all' approach to SBT was unlikely to be effective. This is because individual differences are known to impact on training outcomes using traditional methods, so this is also likely to be the case for SBT. Participants agreed that training is likely to be more effective when tailored to individual learning needs and capabilities. For example, computer-based self-paced instruction (a form of SBT) may be more effective for individuals who are highly self-motivated.

Overall, participants believed that further research is required to address questions regarding the cost-effectiveness of SBT. Furthermore, this research may take considerable time, resources and client engagement, particularly if the long term effectiveness of SBT is to be reliably measured.

How would you engage with industry in order to achieve best return on investment for simulation-based training?

The majority of participants had little previous experience engaging with the simulation industry. In addition, there were no representatives from industry at the workshop to inform the discussions on this topic. Consequently, there was limited discussion regarding this question, although the following points were noted.

- It was generally believed that COTS solutions lacked sufficient flexibility to meet training requirements. It was noted that there is often no access to software source codes and limited opportunities to tailor scenario design to meet training requirements[5]. Participants believed these issues need to be addressed as part of the acquisition process; otherwise this can result in significant additional costs to the client such as payments to the manufacturer for software development.

- It was agreed that there is likely to be value in leveraging and using technology from the gaming industry. However, it was noted that game-based engine models may not be sufficiently mature to meet military training requirements and may also need additional development[6].

- Participants believed that manufacturers of simulation technologies were more focused on incorporating extraneous features ("bells and whistles") that sell the 'realism' of simulators, even though they may have limited or no training benefit. It was acknowledged that industry is driven largely by product sales, which often relies on the ability to sell increased realism to the military customer. Given this situation is unlikely to change, it was recommended that defence clients need to be more rigorous in the acquisition process (as noted previously) to ensure they are getting value-for-money. It was noted that the research community can assist defence clients in this process by helping determine the features in the simulation that are necessary for achieving training benefits. This includes ensuring that these devices provide appropriate feedback to trainees. While many simulators developed by industry include tools for performance analysis and feedback, if the feedback provided by the simulator about trainee performance is not relevant, timely or accurate, the training value of such tools will be limited. In the worst case, such information may even contribute to negative training outcomes.

Where should future research in simulation-based training focus? Where are the high pay-off areas, and why?

Overall, participants believed that future research needed to continue to build up the body of evidence relating to the effectiveness of SBT. However, there were also several specific areas identified for future research. These included;

- Modelling of human behaviour in simulation systems. Participants believed that training non-kinetic/social skills (e.g., cultural awareness, interpersonal skills) was an important area given the nature of current military operations. Current methods for training these skills are often resource intensive (e.g., use of human role players). It was agreed that technology-based solutions could offer more convenience and require fewer resources than traditional methods for this type of training. However,

[5] The simulators developed and used by Monash University Accident Research Centre (MUARC) for civilian road safety research were mentioned as good examples of overcoming limitations with current COTS simulators.
[6] For example, the COTS game Operation Flashpoint was modified into VBS2 in order to meet the requirements of the military customer.

participants believed more research was still needed to ensure the representation of human behaviour in these simulation technologies was sufficiently accurate to support effective training of these skills.

- Validation of simulators and human performance. Participants highlighted that SBT research that examines human performance appears to be based on the assumption that the level of performance (and operator states) observed in the simulated environment is equivalent to (or representative of) the performance that occurs in the real-world. This assumption may not always be supported, and participants suggested that validation of simulators is an area for future research to ensure that performance measurement in SBT is a reliable indicator of real-world performance. Such validation studies would allow researchers to conduct future SBT research with greater confidence that the outcomes are generalisable to the real-world. This research could include assessing the limits of trainee/operator performance using SBT as was highlighted earlier.

- Evaluating the utility of simulation for training cognitive skills. Participants highlighted that due to the complex environments in which military personnel operate, there is a need to invest in training critical thinking and decision-making skills, as well as the ability to cope with ambiguity. Participants acknowledged that training such skills probably works best when the training environment is supportive of making mistakes and provides opportunities for reflection and corrective feedback. It was believed that simulation could be used to help facilitate the training of these specific skills and the potential for microworld simulations was again highlighted.

- Exploring the use of simulation for complex and high-risk missions. Participants noted that SBT can be used to expose trainees to more complex and high-risk scenarios than might be possible in live training due to safety and financial constraints. Consequently, participants believed that SBT could potentially be used to explore limits of human performance in a safe environment, and increase trainee confidence and competency levels for certain skills prior to conducting them on operations. It was noted, however, that the ability to take more risks in the simulator may lead to similar risks being taken in the real world with adverse effects (i.e., negative training). Notwithstanding this last point, participants felt that future research should explore this area further.

3.3 Constraints

The number of workshop attendees was limited to 30 participants on a ‘first come, first served’ basis due to the venue capacity. Also, major budget restrictions within Defence at the time of the workshop limited the ability of personnel to travel interstate, and VTC facilities were not available at the venue. The authors acknowledge that these factors may have excluded the attendance of some stakeholders and hence their viewpoints may not be captured in this document. In particular, there were no ADF representatives at the workshop with a specific interest in SBT. Notwithstanding this, there was a good representation of personnel with significant knowledge and experience in the field of SBT research, so we are confident the views captured reflect the current state of knowledge in the field. Indeed, the key themes that emerged from the workshop were consistent with

the authors' knowledge of SBT, as well as recent literature in this area (see the Reference list at the end of the report for examples).

Due to time constraints, it was not possible to distribute the workshop questions to participants in advance; this may have limited the depth of discussion during the workshop, together with the limited time that was available. If similar workshops are held in future, it is recommended that at least a full day is allocated to allow sufficient time for presentations, discussions, and networking. Furthermore, it is recommended that workshop organisers distribute any background material to attendees well in advance to ensure that participants arrive as prepared as possible and to maximise the time available.

3.4 Additional Material

The reference section of this document contains a list of papers that may be of interest to the reader. It is not intended to be an exhaustive list of references but rather provide the reader with additional resources relating to some of the themes and presentation topics covered in the workshop. These papers cover the following topics: reviews of simulation-based training and education [1-5]; training of cultural awareness, adaptability and leadership skills using simulation [6-7]; performance measurement, simulator fidelity, transfer of training, and training evaluation [8-12].

4. Conclusion

The workshop provided a valuable opportunity to bring together stakeholders working in the area of SBT and to capture their viewpoints and share lessons. The four main questions provided an organising structure for the workshop and several key lessons emerged from the presentations and discussions. These lessons are relevant to both researchers and defence stakeholders.

- More empirical research is needed in order to improve the quality of advice that can be provided to clients regarding the cost-effectiveness of SBT; in particular
    - better understanding the relationship between simulator fidelity and the effectiveness of SBT;
    - determining which skills are more effectively trained using SBT;
    - measuring differences in skill acquisition and retention rates for SBT and other training methods; and
    - developing more reliable measures of effectiveness for SBT.
- Simulation offers potential advantages over conventional training in a number of areas; high-pay off areas for future research include:
    - training beyond competency and exploring the limits of operator performance;
    - training for complex and high-risk missions; and
    - training critical thinking, decision making and social skills.
- Basic principles of training and education still need to be applied to achieve effective outcomes, including:
    - use of guided instruction; and
    - consideration of individual differences.

- The acquisition of SBT capability should follow a more rigorous process to ensure 'value-for-money', including:
    - clearly articulating training requirements;
    - using training requirements to identify potential training solutions and inform simulation specifications; and
    - conducting a cost-benefit analysis to compare different training options, including consideration of alternatives to SBT such as simple training aids.

Overall, more empirical studies are needed before the questions covered in the workshop can be fully addressed, and the research community is able to provide more informed advice to defence clients about the use of SBT. Despite the limited time available, participants believed that the workshop was valuable in raising their awareness of research being conducted into SBT and discussing some of the key issues in this area. The above lessons will provide a useful starting point for further discussion regarding SBT between researchers, defence clients and industry.

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Reviews of simulation-based training and education

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15. McLean, G., Lambeth, S., Pongracic, H., Skinner, M., McInerney, R., Mavin, T., & Bryant, P. (2012). *Integrating Flight Simulation into* ab initio *Pilot Training*. Paper presented at DHSS 2012, Adelaide, South Australia.

16. Skinner, M. (2012). *Exercise Black Skies 2012: Evaluation of the effectiveness of synthetic collective training for an AEW&C Team.* Paper presented at DHSS 2012, Adelaide, South Australia.

17. Hanson, J., Wearing, A., Smith, G, Nguyen, T., Goodburn, D., & Davis, S. (2012). *Military Meta-Cognitive Profiles (MMCPs) and more effective decision making*. Paper presented at DHSS 2012, Adelaide, South Australia.

Appendix A: Workshop Attendees

The following table lists the workshop attendees and their affiliation.

Surname	First Name	Organisation
Bollard	Lauren	University of Adelaide
Cockshell	Susan	DSTO MOD
Coombs	Gary	DSTO LOD
Corkill	Jeff	Security Research Centre, Edith Cowan University
Davis	Steven	DSTO C3ID
Ducharme	Michel	Defence Research & Development Canada
Fletcher	Kingsley	DSTO MOD
Goodburn	Daniel	DSTO C3ID
Grisogono	Anne-Marie	DSTO LOD
Hanna	Suzanne	DSTO MOD
Hansen	John	DSTO C3ID
Hoggan	Ben	University of Adelaide
Iremonger	Gareth	NZ Defence Force
Jacques	Philip	DSTO LOD
King	Justin	University of Melbourne
Lenne	Mike	Monash University Accident Research Centre
Magdas	Elisabeth	University of Sydney
Martin	David	Australian Institute of Sport
McLean	Greg	DSTO AOD
Richardson	Andy	Defence Technology Agency, NZ
Savage	Robert	DSTO HPPD
Stephens	Ashley	DSTO LOD
Tavender	Kim	Air Force Organisational Psychology
Temby	Philip	DSTO LOD
Thiele	Luke	Sydac Pty Ltd
Whitney	Susannah	DSTO LOD
Yeates	Kirsty	Directorate Strategic Workforce Planning

Appendix B: Summary of DSTO studies

Utility of VBS2 Simulation for Individual and Collective Training

Dr Susannah Whitney (DSTO LOD) gave a presentation on two studies looking at the effectiveness of the first-person simulation VBS2 for training military skills. The first study looked at the use of VBS2 for training section attack to novice infantry trainees, which is an example of collective training in a collective context [13]. The study compared the pre- and post-training performance of two teams at section attack, where one team had conducted training using VBS2, and the other team had conducted training in the field (i.e. conventional training). The study outcomes showed that while the performance of the field-based training group increased significantly after training, there was no change in performance for the group trained using VBS2. This outcome shows that the simulation has little utility for training section attack procedures for this population of trainees. The main reasons for this outcome were limitations in the simulator fidelity, relative to the requirements for the task being conducted. Specifically, there was a very large difference in the physical skills required to conduct section attack in the field, compared with how these skills were executed in VBS2. In addition, the narrow field-of-view did not allow the degree of team awareness required for this collective training activity. The overall implication of these outcomes is that (1) VBS2 may have limited utility for other collective infantry tasks and (2) the nominally cheaper method of training was not effective.

The second study looked at the use of VBS2 for Explosive Hazard Awareness Protection Training, where the aim is to train vehicle convoy commanders to respond to explosive hazards [14]. In contrast to the section attack task, this is an example of individual training in a collective context. The study compared the training outcomes for traditional training and VBS2 and provided some evidence to suggest that VBS2 was a useful supplement to traditional training methods. Some of the limitations in VBS2 identified during the section attack study (e.g., limited field-of-view) were also identified during this study, but did not appear to be as critical. The two studies highlighted that the utility of a given simulation is dependent on the task being trained. In these cases VBS2 was found to be ineffective for collective training in a specific collective context but showed promise for individual training in a different collective context. The implication here is that it is critical to specify the task and context in which the training is conducted and not simply describe a simulation as being effective (or not effective) for training.

Utility of Simulation for Pilot Training

Dr Greg McLean (DSTO AOD) gave a presentation on the use of SBT in an *ab initio* pilot training course [15]. The initial findings of the study demonstrated that use of the simulation resulted in a reduction in live flying hours, but an increase in total training time. Overall, there was little difference in cost between an all live and blended training program, although students may have felt more confident with initial familiarisation in the simulator rather than going straight to the real aircraft. This was an interesting finding, given that use of simulation in the air domain is often held up as an example of the cost-benefit advantages associated with SBT. The lesson here is that it should not be assumed that use of simulation automatically achieves cost-savings.

Use of Simulation for Command and Control Team Training

Dr Greg McLean (DSTO AOD) gave a second presentation on the use of synthetic environments as preparation for Command and Control (C2) teams in live exercises [16]. Exercise Black Skies 2012 (EBS12) involved Air Battle Management (ABM) and Airborne Early Warning and Control (AEW&C) Teams conducting synthetic training scenarios matched to the missions they would conduct eight weeks later at a live exercise (Pitch Black 12: PB12). During EBS12, the performance of both teams improved across a number of mission objective and teamwork dimensions, consistent with the training being effective. Furthermore, the subsequent performance of the EBS12 AEW&C team during PB12 provided evidence that the benefits of EBS12 transferred to the live exercise. It was noted that in order to achieve this outcome, a 4:1 ratio of white force to exercise participants was required; that is, the training audience was only 20% of the total number of participants. The implication is that the conduct of such realistic training is highly resource intensive, and hence may not be achievable on a frequent basis if the client incorporated these methods into regular training. Subsequent research will examine whether this ratio can be reduced (e.g., through use of automation, simulated white force, non-expert role players) without compromising the training benefit.

Use of Simulation in Military Education

Mr John Hansen gave a presentation on the use of simulation for professional military education, in particular some work conducted within DSTO C3ID looking at the use of microworlds for exploring C2 issues [17]. The presentation discussed the characteristics of a good microworld simulation and how this medium could be used for making individuals aware of their own particular thinking styles and how this impacted on their decision making. It was noted that certain thinking styles are characterised by a number of cognitive biases and are unsuited to dealing with uncertainty and ambiguity; conditions that are often faced by decision makers in the military domain (as well as other domains). The implication is that microworld simulations could be used to help military commanders and leaders to improve their decision making abilities. The presenter also noted that some of the issues that are relevant for SBT will also be important for education; however there will also be differences. This point was taken up in a subsequent presentation by Dr Daniel Goodburn (also from C3ID), who discussed some of the key points from a review of the field of simulation in education [4]. The review noted that future work could potentially focus on designing simulation which enables a more facilitated approach to education in which expert practitioners and students explore complex problems in order for the student to learn how to think (rather than what to think). This idea aligns with the research into the use of Microworlds for improving decision making abilities outlined previously. At present, this capability appears to be underutilised. The implication is that there are opportunities being missed in terms of enhancing educational practices through the use of simulation.

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19. ABSTRACT

This report summarises key outcomes from a half-day workshop on Simulation in Training held as part of the Defence Human Sciences Symposium (DHSS) in November 2012. The workshop involved presentations on simulation-based training (SBT) research within DSTO, and syndicate group discussions aimed at addressing key questions relating to SBT. The workshop outcomes highlighted the need for the research community to obtain more evidence regarding the cost-effectiveness of simulation and for the defence client to adopt more rigorous processes when acquiring and evaluating simulation. At present, knowledge gaps are limiting the research community's ability to provide Australian Defence Force (ADF) customers with sound advice regarding the effectiveness of SBT and for the ADF to fully realise the benefits associated with SBT.